

UCLA

MUSIC

IV

PROGRAM

PP

A

1-1a

5-6

7-10

11-12

13-16

17

17

17

18

18

18, 19, 20

20, 21

22

23

24-25

INTRO

OUTLINE OF PROGRAM (JOHN GARDNER)

UNIT GENERATORS

4 SAMPLE INSTR DESIGNED

AT STRANG'S SEMINAR AT
LONG BEACH FEB 69 ORCH #

CONVERSION FNS FOR #18

ENVELOPE AND TIMBRE FNS

GEN 07 GEN 09; AMPLITUDE SCALING

ARBITRARY CONVENTIONS

STORAGE PROVISIONS

LEGAL INPUTS

USE OF P-FIELDS

SCORE - GENERAL FORMAT

CUT DELIC

ORCH DELIC

EQUAL-TEMP. SCALE IN CPS

BIBL OF COMPUTER MUSIC

COMPUTER MUSIC

Gerald Strang

The computer sound synthesis program with which my COMPOSITIONS were produced was originally developed at Bell Telephone Laboratories by Max V. Mathews and John R. Pierce. My own version, operative at UCLA, owes much to the generous cooperation and assistance of Dr. Leon Knopoff and Dr. John Gardner. The following description gives a general idea of how the program works.

The composer designs an "orchestra" made up of "instruments" which are computer subroutines. Each instrument accepts input data (such as pitch, loudness, tone quality, attack-decay patterns, duration, rhythm, rests) in numerical form, combines and processes these data, and produces a succession of instantaneous output values. The instantaneous output values of all the instruments are added to form "samples." The original program produced 10,000 samples per second; the UCLA version operates as high as 25,000 samples per second. The usable band width is slightly less than half the sample frequency.

The composer can store a single cycle of any waveform (sound quality) that can be described in terms of amplitude vs. time, including a Fourier synthesis (fundamental-plus-overtone complex). The computer can then repeat it at any desired frequency. Any parameter can be systematically manipulated, modified, permuted or elaborated by supplying appropriate instructions.

Sound is produced by feeding the computer output to a digital-to-analog converter, which converts the numerical values to a varying voltage. This voltage resembles the signal produced by a microphone. It may be amplified and recorded on tape in the same way.

John Gardner

Feb 15, 1969

MUSIC IV Program at UCLA - General

Outline of Program

1) Det. sound desired - define it. Until now sounds were det. by specifying already existing instruments. Computer instruments must be created.

2) PLF, PLS, GEN, CVT, ORCHESTRA

(GEN fns may or may not already exist
(GEN07 or GEN09 are 2 in existence at the
moment, but others could be written.

SOURCE DECK - decks from which
the computer will produce commands which
the " " can use
OBJECT DECK - the commands themselves

3) Score

DATA DECK
Per Section or Per Run
GEN
PLF
PLS
SEC
ETC
Instr. no.

4) Computation - Digital out

5) Conversion - Dig - to - Analog

3 PASSES

PASS I

(A) DATA Cards ~~Read~~ Individually 1000/section
Read
Processed (Edited - adds zeroes, etc.)
Stored (tape)

(B) PLF Cards 15/program

The fn. of this card is to call in a subroutine. GEN & CVT are sub routines, but have to be written out. PLF routines generate the cards of a section on the basis of previous commands which tell the computer how it is to do so.

It is possible to call in data to be operated upon by a PLF in the 1st PASS. The PLF routine consists of a number of if $\Rightarrow$ then type FORTRAN statements which will act upon data provided according to the criteria of those statements.

PLF is $\therefore$ a means of ~~getting~~ generating data and of calling in a subroutine, the data outline of which can be specified according to ANY procedure.

PASS II

- (A) GEN fns are created in this pass
- (B) INSERT - causes instrument called upon in OP column to be inserted, and at the same time, calls in the CVT for that instrument.
- (C) REMOVE - causes instrument listed in OP column which was inserted to be removed, so the next instrument no. in the OP column can be read.
- (D) PLAY
- (E) TER

PASS II

- (A) SORTS SECTION
- (B) COMPUTES OPTIONAL SUBROUTINES
(e.g. SCALING OR PLS)
- (C) CREATES A LISTING

- ① 1000 cards / section are allowed.
 - ② Be careful! PLF routines generate many cards from just one. Also, each note card generates an end card, i.e. only 500 note-cards/section are allowed.
 - ③ Optional Subroutines
 - ⓐ SCALE (e.g. amplitude scaling from 1-10)
 - ⓑ PLS - a subroutine which calls in an operation over an entire section (e.g. Retrograde a section, or, speed it up, etc.)
- NEW SECTIONS ARE GENERATED, in contrast to PLF which generates cards within a section. Also, any specific parameter or instrument can be acted upon by PLS, and altered automatically.

MUSIC IV PROGRAM

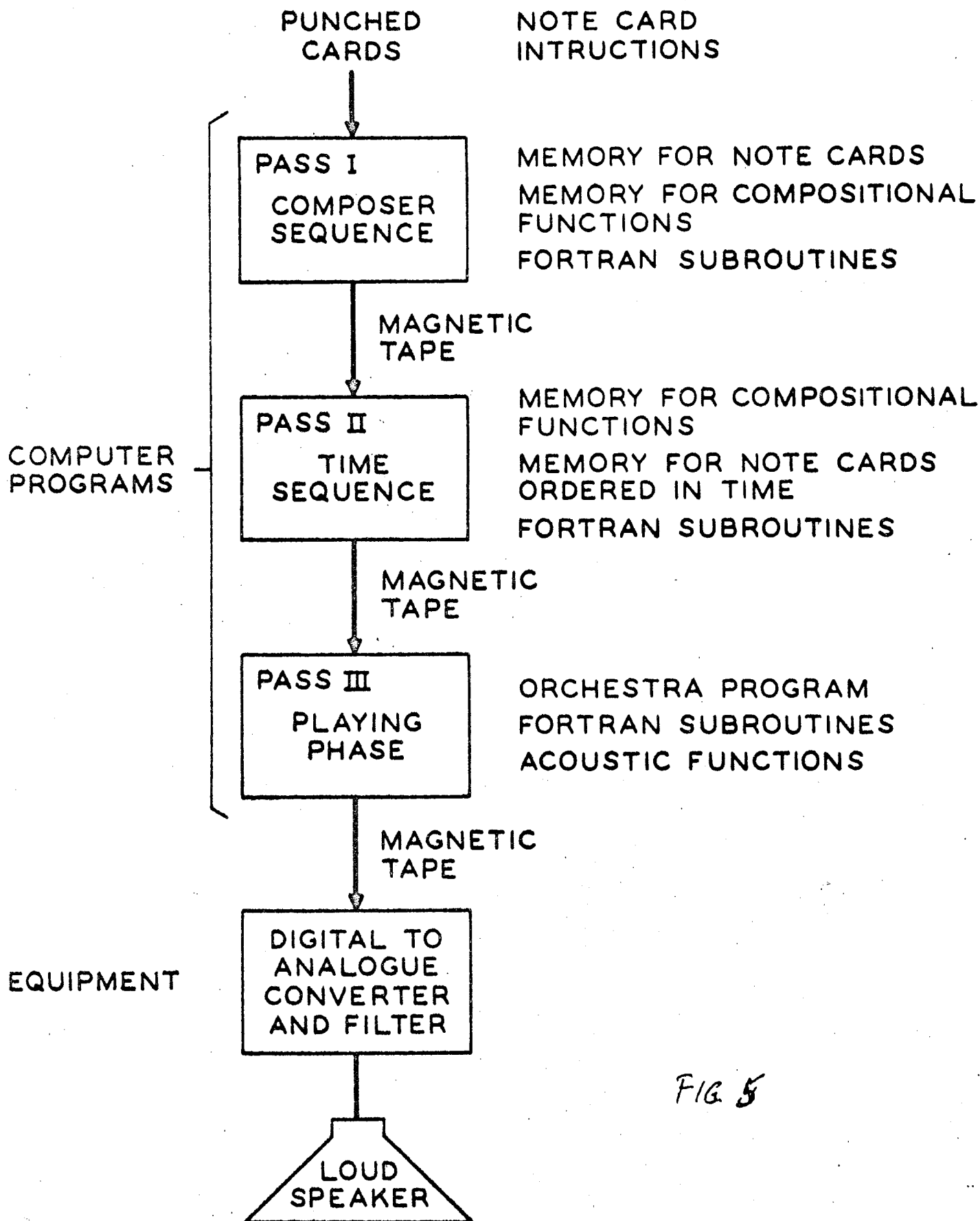
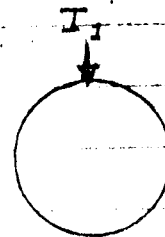


FIG 5

MUSIC II

UNIT GENERATORS

ENDINS

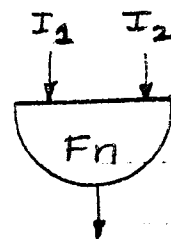


OSCIL
COSCIL

$$I_1 = \text{AMPL}$$

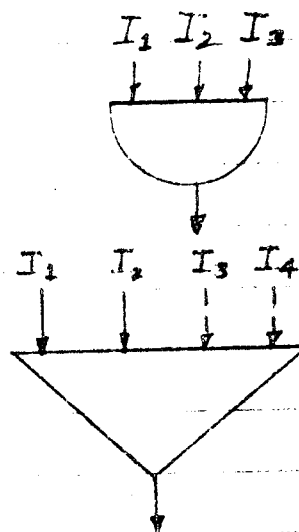
$$I_2 = \frac{I_1 \times \text{SNMBR}}{\text{FNMBR}}$$

$F = \text{STORED FUNCTION}$



VOSCIL
VCOSCL

$I_3 = \text{STORED F.}$



ADD 2
ADD 3
ADD 4

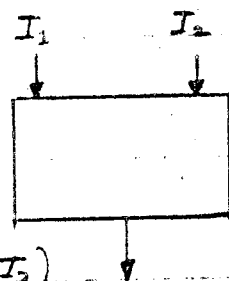
RANDH

$$I_1 = \frac{\text{BW}}{2}$$

$$I_2 = \text{RATE}$$

MAGN. $I_2 = -1 < +1$

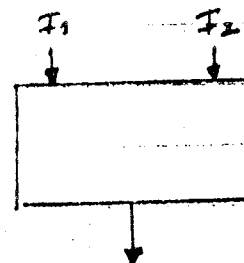
$$\phi = I_1 \times \text{RANDOM FUNCTION}(I_2)$$



HOLDS
RANDOM NUM

RANDI

AS ABOVE

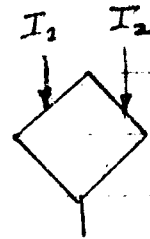


INTERPOL

MUSIC IV

UNIT GENERATORS

MULT



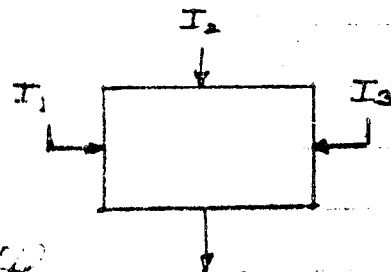
FILTER

$I_1 = CF$

$I_2 = SIGNAL$

$I_3 = BW$

NOTE: SPECIAL CVTs REQUIRED



RESON (RESONATOR - NOT IN USE)

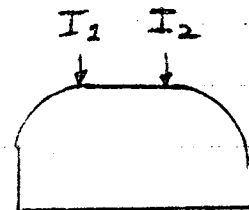
EXPEN (EXPONENTIAL ENV. GENERATOR)

LINEN (LINEAR ENV. GEN.)

INTP2 LINEAR INTERPOLATOR

$I_1 = \text{INITIAL VALUE}$

$I_2 = \text{FINAL VALUE}$



I_2 REQUIRES SPECIAL CVT
OF THE FORM:

$$C_n = I_2 - I_1 / (P(3) * SNMBR)$$

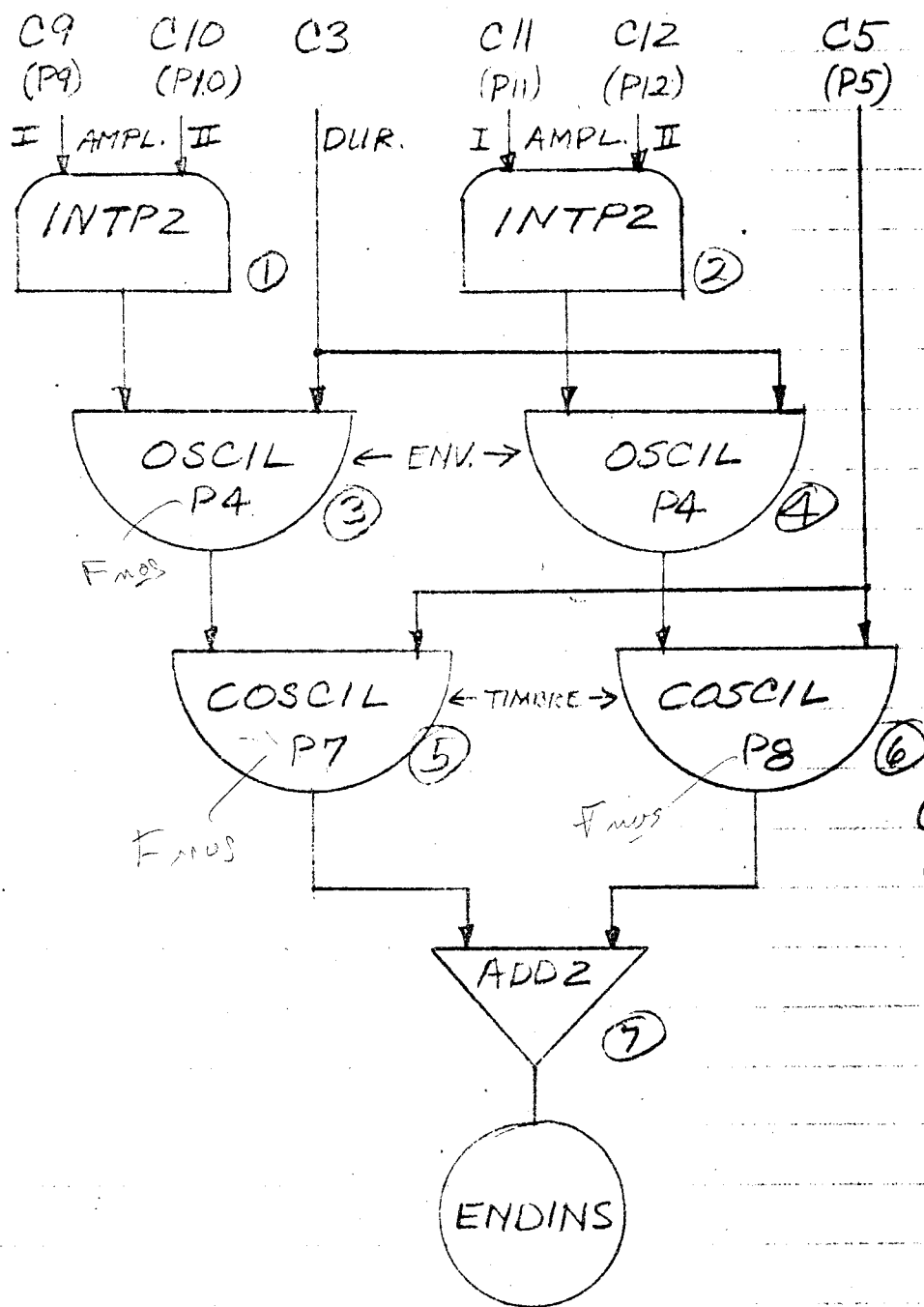
[P(3) = DURATION (SEC.)]

WHOP

INSTRUMENT #1

FEB. 1969

7



Subd. for F

INSTR	WHOP	
INTP2	C9, C10	U1
INTP2	C11, C12	U2
OSCIL	U1, C3, P4	U3
OSCIL	U2, C3, P4	U4
COSCIL	U3, C5, P7	U5
COSCIL	U4, C5, P8	U6
ADD2	U5, U6	U7
ENDINS	WHOP	

C3 = FOURS / P(3)
C5 = FOURS * P(5)

$C9 = 10.0 ** (P(9)/20.0)$
 $C10 = ((10.0 ** (P(10)/20.0)) - (10.0 ** (P(9)/20.0))) / ((P(3) * SNMBR))$
 $C11 = (\text{See } C9 - \text{use } P11)$
 $C12 = (\text{See } C10 - \text{use } P12 \& P11)$

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
	START	DUR	ENV	FREQ		TIMBRE I	TIMBRE II	AMPL I	AMPL II	AMPL I	AMPL II
1								U1		U2	

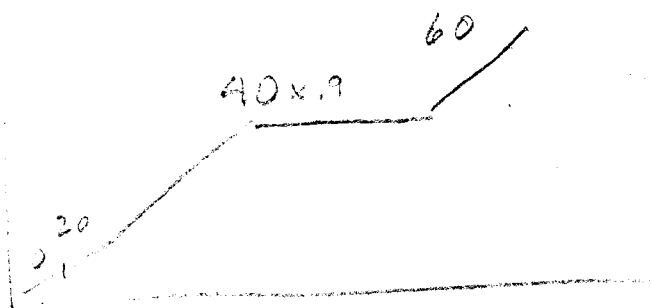
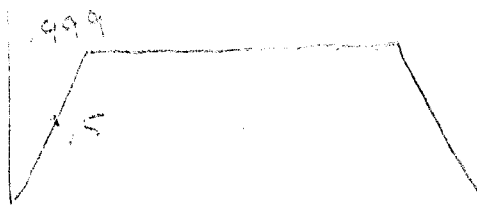
Envelope

0 — .9997

Amplitude

0 — 60

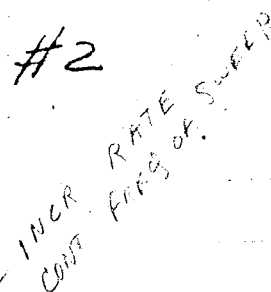
According to envelope - amplitude
is multiplied $\times$ value of envelope
to get final Computer Output -
Amp



40 x .9997 60 x .9997

20 x .5
~~0 x 0~~

INSTRUMENT #2



INSTR	HORN
OSCIL	C4,C3,P8
COSCIL	C6,C7,P9
ADD2	C5,U2
COSCIL	U1,U3,P10
ENDINS	HORN

$$\begin{aligned} C3 &= \text{FOURS} / P(3) \\ C4 &= 10.0 * (P(4) / 20.0) \\ C5 &= \text{FOURS} * P(5) \\ C6 &= \text{FOURS} * P(5) * P(6) \\ C7 &= \text{FOURS} * P(7) \end{aligned}$$

CENTER FREQ

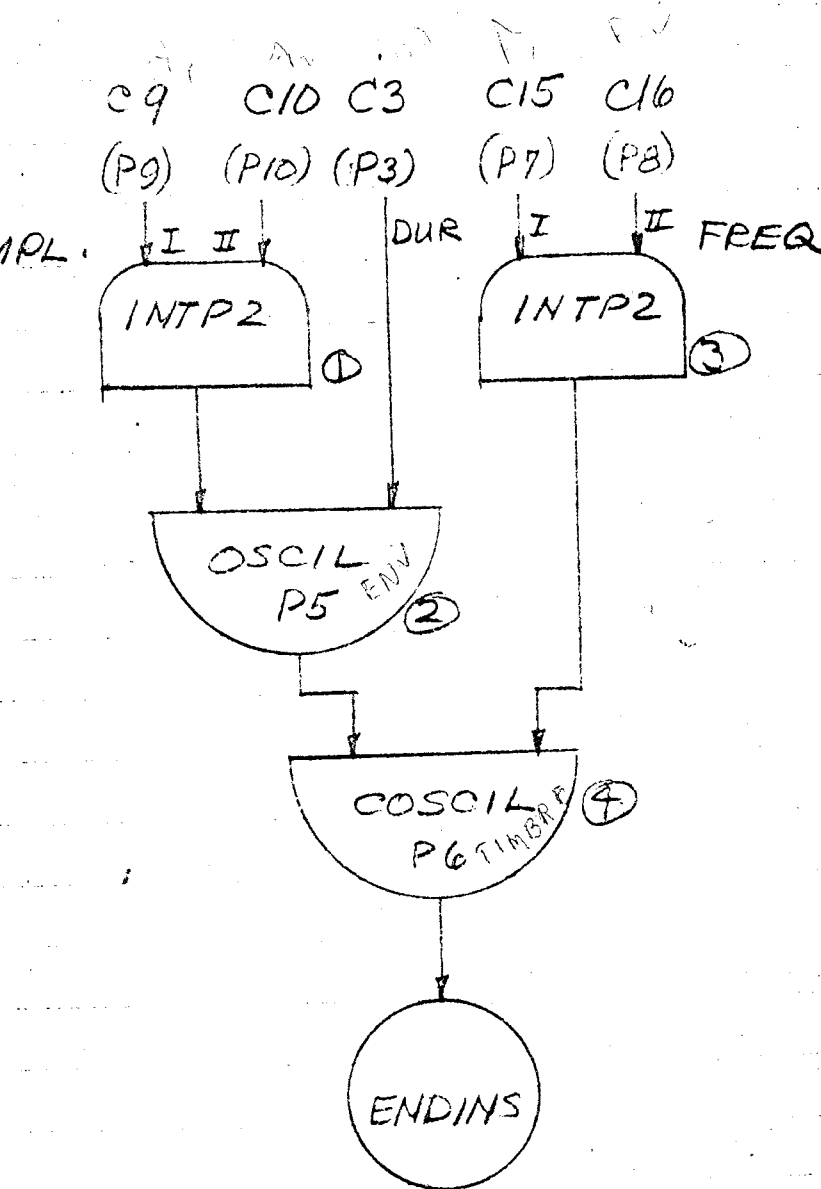
P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
	2	T ₁ START	T ₂ DUR	AMPL.	FREQ.	VIBR. RANGE (%)	VIBR. RATE	ENV.	VIBR. WAVE FORM	TIM- BRE		

GLIDE

INSTRUMENT #3

FEB. 1969

9



INSTR GLIDE

INTP2 C9,C10 U1

OSCIL U1,C3,P5 U2

INTP2 C15,C16 U3

COSCIL U2,U3,P6 U4

ENDINS GLIDE

$$C3 = \text{FOURS} / P(3)$$

$$C9 = 10.0 ** (P(9) / 20.0)$$

$$C16 = ((10.0 ** (P(10) / 20.0)) - (10.0 ** (P(9) / 20.0))) / (P(3) * \text{SNMBR})$$

$$C15 = \text{FOURS} * P(7)$$

$$C16 = \text{FOURS} * (P(8) - P(7)) / (P(3) * \text{SNMBR})$$

P	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
		START	DUR		ENV	TIMBRE	FREQ	FREQ	AMPL	AMPL	
							I	II	I	II	

3

CONVERSION FUNCTIONS - ORCH. #18 FEB, 1969

		INSTR. #
C3 = FOURS / P(3)	DUR. - SEC	1, 2, 3
C4 = 10.0 ** (P(4)/20.0)	AMPL. - DB	2
C5 = FOURS * P(5)	FREQ - CPS	2
C6 = FOURS * P(5) * P(6) * .01	VIBR. RANGE - %	2
C7 = FOURS * P(7)	FREQ - CPS	2
C9 = 10.0 ** (P(9)/20.0)	AMPL. - DB	1, 3
C10 = ((10.0 ** (P(10)/20.0)) - (10.0 ** (P(9)/20.0))) / (P(3) * SNMGR)	FINAL AMPL. - DB	1, 3
C11 = 10.0 ** (P(11)/20.0)	AMPL.	1
C12 = ((10.0 ** (P(12)/20.0)) - (10.0 ** (P(11)/20.0))) / (P(3) * SNMGR)	FINAL AMPL.	1
C15 = FOURS * P(7)	FREQ - CPS	3
C16 = FOURS * (P(8) - P(7)) / (P(3) * SNMGR)	FINAL FREQ	3

ADDED CVTs - ORCH #18

FEB. 1969

$$C8 = ((10.0 ** (P(5)/20.0)) - (10.0 ** (P(4)/20.0))) / (P(3) * SNMBR)$$

$$C13 = FOURS * P(6)$$

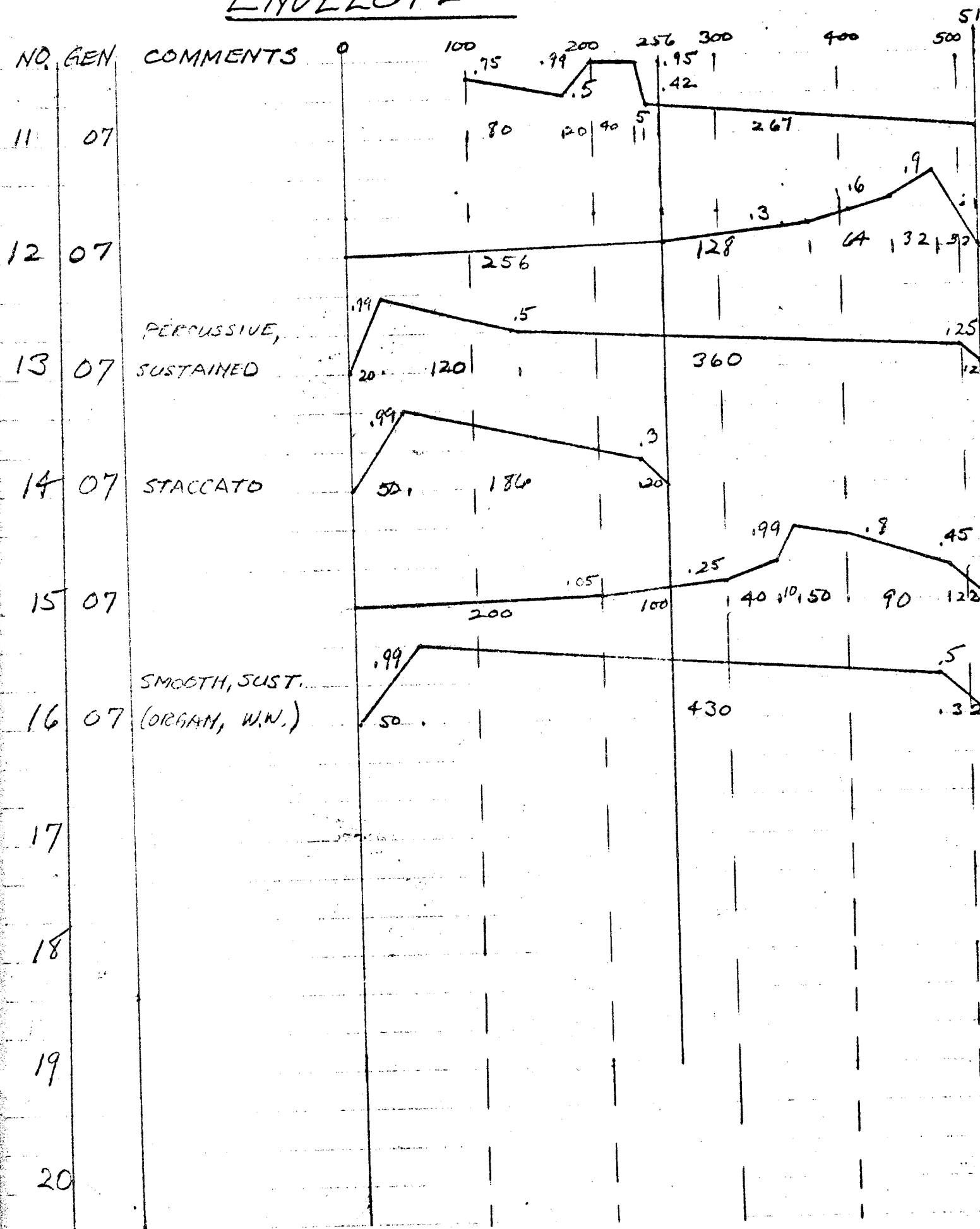
$$C14 = FOURS * P(8)$$

$$C17 = FOURS * P(9)$$

$$C18 = FOURS * P(10)$$

	INSTR. #.
FINAL AMBL DB	4
PITCH CF-CPS	4
RATE CF-CPS	4
RATE BW/2-CPS	4
RATE TRIGGER CPS	4

ENVELOPES



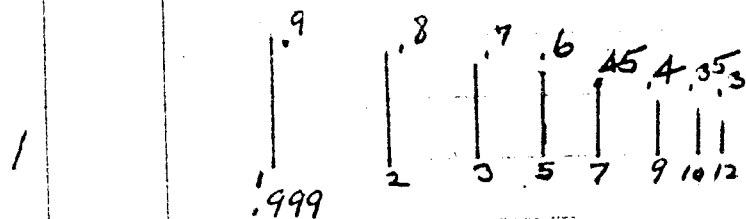
TIMBRES

PN
E.No.

GEN

HARMONICS

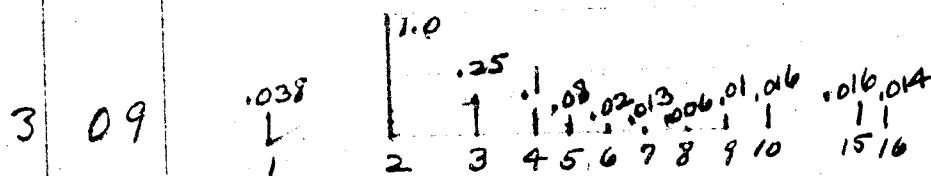
COMMENTS



RICH, DENSE
(ORGAN TRUMPET)

2 09

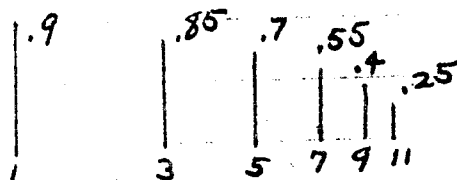
SINE



4

5 09

LOW CLARINET



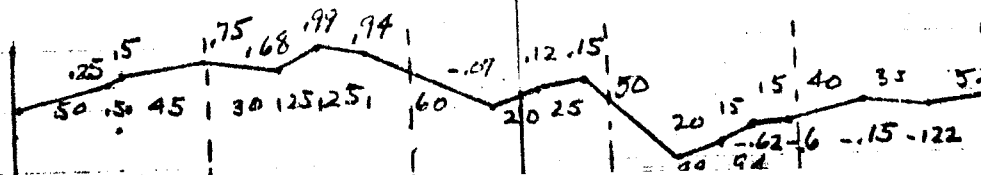
6

7

8

9

10 07



ENVUELOS

ORCH. #18

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
OP	1-3	←12	←18	←24	←30	←36	←42	←48	←54	←60	←66	←72
GEN	07	11	0	25	.5	75	.75	80	.5	20	.99	73
ETC				40	.95	5	.42	267	0			→
GEN	09	12		0	256	15	128	13	64	16		
ETC												
GEN	07	12	0	256	.15	128	.3	64	.6	32	.9	
ETC				32	0							
GEN	07	13	0	20	.99	120	.5	360	.25	12	0	
ETC												
GEN	07	14	0	50	.99	186	.3	20	0			
ETC												
GEN	07	15	0	200	.05	100	.25	40	.5	10	.99	
ETC				50	.8	90	.45	22	0			
GEN	07	16	0	50	.99	430	.5	32	0			

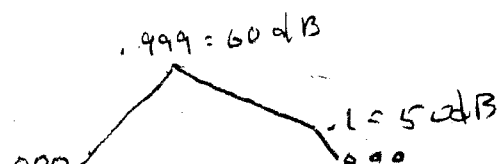
OP	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
1-3	←6	←12	←18	←24	←30	←36	←42	←48	←54	←60	←66	←72 73 →
GEN 09	1		.9	1	0	1	5/12	.8	2	0	2	5/12
ETC			.7	3	0	3	5/12	.6	5	0	4	5/12
ETC			.45	7	0	5	5/12	.4	9	0	6	5/12
ETC			.35	10	0	7	5/12	.3	12	0	8	5/12
GEN 09	2		.999	1	0	1	5/12					
GEN 09	3		.038	1	0	1	5/12	1.0	2	5/1	1	5/12
ETC			.25	3	102	1	5/12	.1	4	153	1	5/12
ETC			.68	5	204	1	5/12	.02	6	256	1	5/12
ETC			.013	7	307	1	5/12	.006	8	358	1	5/12
ETC			.01	9	409	1	5/12	.016	10	460	1	5/12
ETC			.016	15	485	1	5/12	.014	16	25	1	5/12

OP	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
1-3	←6	←12	←18	←24	←30	←36	←42	←48	←54	←60	←66	←72 73 →
GEN 09	5		.9	1	0	1	5/12	.85	3	200	1	5/12
ETC			.7	5	280	1	5/12	.55	7	300	1	5/12
ETC			.4	9	385	1	5/12	.25	11	256	1	5/12

GEN 07; GEN 09

IN SPECIFYING RELATIVE AMPLITUDE,
SCALED +1.0 TO -1.0, THE CORRESPONDENCE TO DECIBEL RATIOS (IF 1.0 = 60 DB) IS:

No. in PROGRAM	db
1.0	60
.1	50
.01	40
.001	30
.0001	20



ARBITRARY CONVENTIONS:

USE: F1 - F10 TIME
F2 SINE
F11 - F20 ENVELOPE

STORAGE IS PROVIDED FOR:

- 15 PLF ROUTINES } Special Routines where computation takes care of 1st or 2nd pass.
- 15 PLS " }
- 20 F STORAGE BLOCKS OF 512 WORDS
- 100 CVT FUNCTIONS
- 1000 NOTE CARD IMAGES PER SECTION
- 65 P - FIELDS (PER NOTE)
- 30 U - UNIT GENERATORS (PER INSTR.)
- 20 K - CONSTANTS

<u>OP Code</u>	<u>Numerical Equivalence</u>	<u>Meaning</u>
bbb*	1	Play a Note in Pass III
GEN	4	Generate Function in Pass III
SPF	5	Set Parameter in Pass I (SETS T)
TER	6	Terminate Composition
PLF	8	Call Subroutine in Pass I
SEC	9	Terminate Section
SPS	10	Set Parameter in Pass II (SETS T)
ETC	11	Continuation Card
PLS	12	Call Subroutine in Pass II
n	13	Store a Note Card in Pass I or Pass II. n is integer between 1 and 999.

(MUST BE CALLED BY
PLF OR PLS)

Use the following sps card at the head of the score to permit specifying amplitude in DB:

1 6 12
SPS 30 9

Format for CVT deck:

1 78 16
\$IEFTC CX DECK,LIST,REF

FUNCTION CVTX(DUMMY)

- COMMON/P/ P(480), OP, DEL

- COMMON/RATE/ SNMBR, SNMBRI, FNMBR, FNMBRI, FOVRS

- INTEGER SNMBRI, FNMBRI

CVTX =

Function defined by arithmetic statement

RETURN

END

Definition of terms used in CVT deck:

X is the number of the function. X.GE.1, X.LE.100

SNMBR is the number of samples per second

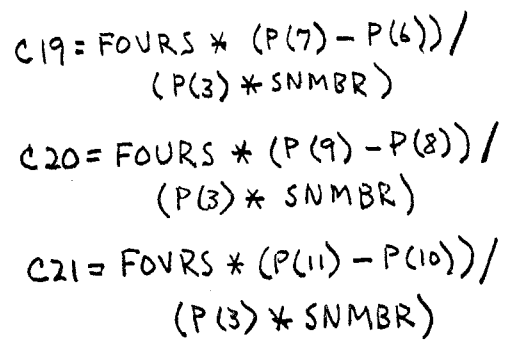
SNMBRI is the fixed point form of SNMBR

FNMBR is the number of samples in an F function (=512)

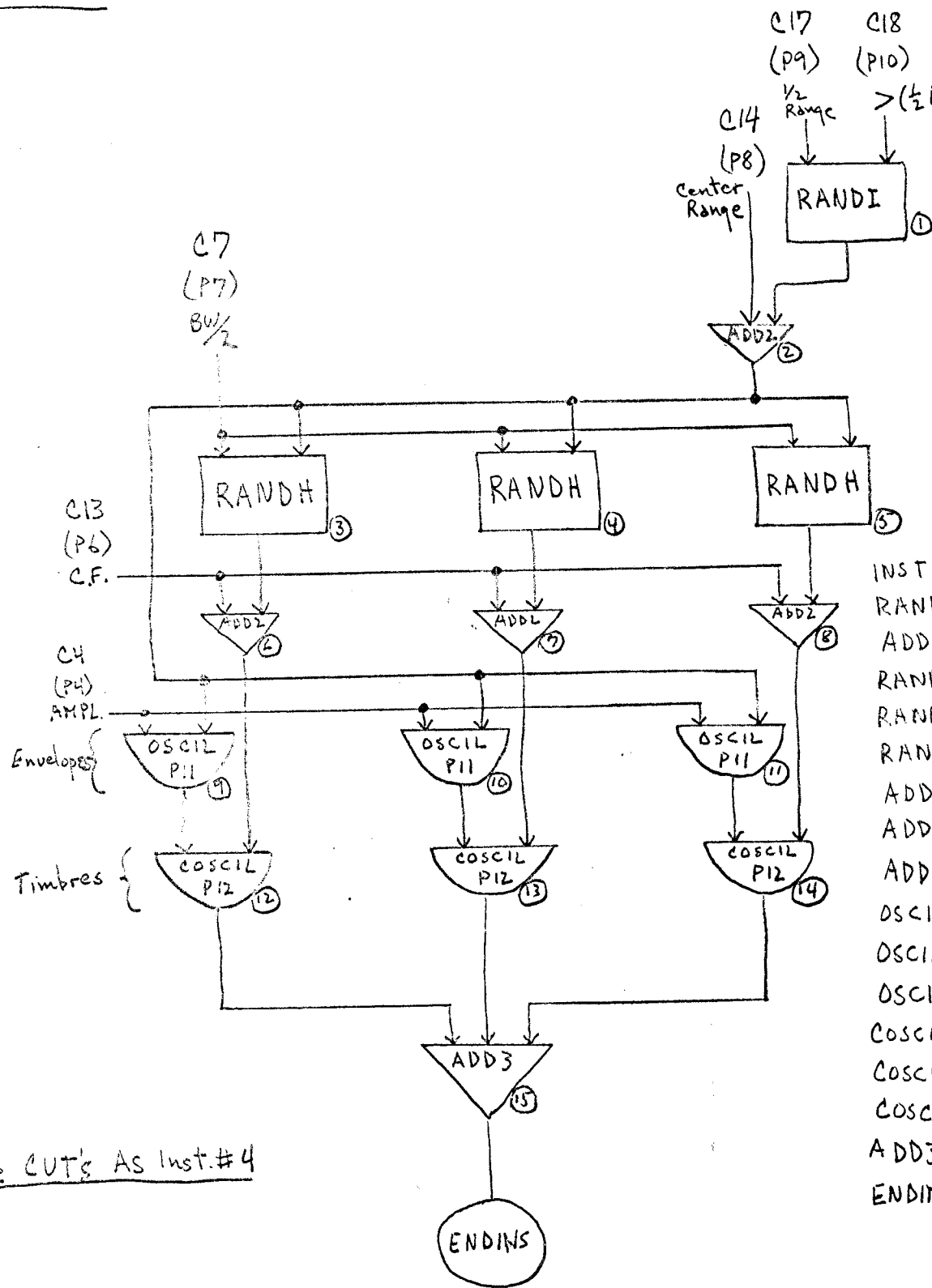
FNMBRI is the fixed point form of FNMBR

FOVRS = FNMBR/SNMBR

each CVT has 8 cards in the following seq.
space char not effect program



P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
	START	DUR	AMPL.		CF		$\frac{BW}{2}$		RATE		Timbre
			I	II	I	II	I	II	I	II	



INSTR	TRIAD	
RANDI	C17, C18	u1
ADD2	C14, u1	u2
RANDH	C7, u2	u3
RANDH	C7, u2	u4
RANDH	C7, u2	u5
ADD2	C13, u3	u6
ADD2	C13, u4	u7
ADD2	C13, u5	u8
OSCIL	C4, u2, P11	u9
OSCIL	C4, u2, P11	u10
OSCIL	C4, u2, P11	u11
COSCIL	u9, u6, P12	u12
COSCIL	u10, u7, P12	u13
COSCIL	u11, u8, P12	u14
ADD3	u12, u13, u14	u15
ENDINS	TRIAD	

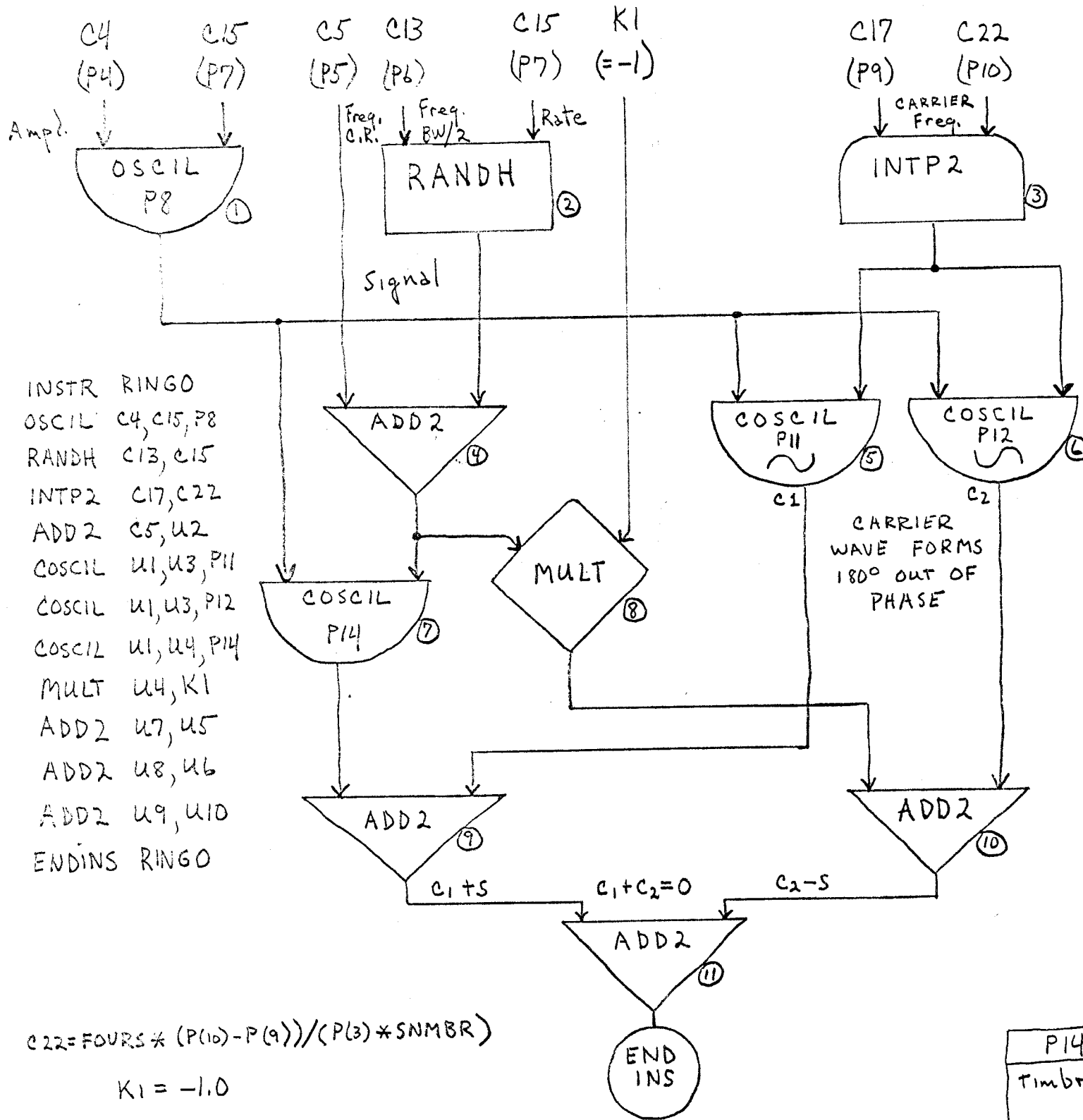
Same CUT'S AS Inst. #4

OP	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
	7	START	DUR	AMPL	—	PITCH	CF	CF	RATE	Trigger	ENV.	Tim
						BW/2			BW/2			

RINGO

Instr. #8
Orch. #18

5/61



$$C22 = \text{FOURS} * (P(10) - P(9)) / (P(3) * \text{SNMBR})$$

$$K1 = -1.0$$

OP	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
	8	ST.	DUR.	AMPL.	Freq.	SIGNAL Range	RATE	ENV.	CARRIER I FREQ.	CARRIER II FREQ.	CARRIER WAVE FORM I	CARRIER WAVE FORM II

P14
Timbr

CVT Deck

(100 CVT'S MAX)

1	7	8	16
\$IBFTC		C1	DECK
	FUNCTION CVT1 (DUMMY)		
	COMMON/P/P(480), OP, DEL		

↓
etc see sheet

END

*			
\$IBFTC		C2	DECK

↓
END

Each CVT statement contains 8 cards
Card 6 is the Formula of the fu.
which is defined by arithmetic
statement.

Occ Deck, preceded by CVT's

- * asterisk is a comment card in FORTRAN
- * Information listed begins in col. 8
- * Name of Instr. (5 letters max) in col 16
- * Un, Cn, Pn - also begin in col 16
- * no spacing permitted
- * use comma to separate terms.
- * after 1st space, the rest of the card can be used for COMMENT
- * Do not use col. 72 or following

format

8 * OCH, FEB 69 INSTR INTP2 ↓ ADD2 ENDINS * INSTR etc ENDINS * PLAY	16 WHOP C9, C10 ↓ U5, U6 WHOP GLIDE etc GLIDE	U1 ↓ U7 etc
---	--	---

1 2 3 etc

(WHOP, ~~GLIDE~~, etc)

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